**OA-22**

# High-field nonlinear properties and characteristics of domain wall motion of $Fe_2O_3$ doped PMnS-PZN-PZT ceramics

H. Zhang, W. Jin, J. Zhou, J. Shen, J. Zhou, W. Chen*

*State Key Laboratory of Advanced Technology for Materials Synthesis and Processing, School of Materials Science and Engineering, Wuhan University of Technology, Wuhan 430070, P. R. China*
**chenw@whut.edu.cn*

High-power piezoelectric devices, such as ultrasonic motors, underwater acoustic transducers, piezoelectric transformers, etc., require ceramics with large piezoelectric responses and, particularly, low losses [1, 2]. In our previous work, $Fe_2O_3$ doped $Pb(Mn_{1/3}Sb_{2/3})O_3$-$Pb(Zn_{1/3}Nb_{2/3})O_3$-$Pb(Zr, Ti)O_3$ (PMnS-PZN-PZT) ceramics was found to possess a relatively high piezoelectric property ($d_{33}$ = 356 pC/N) and an extremely low dielectric loss (tan $\delta = 1.2 \times 10^{-3}$) [3], showing that the ceramics are promising for high-power applications. From a fundamental point of view, understanding the origin of the low losses of this excellent material is of scientific interest, which would offer important clues for the development of piezoelectric ceramics with more superior high-power performance. Generally, the domain wall motion is the dominant loss origin for dense piezoelectric ceramics [4]. Therefore, the characterization of domain wall motion is the key to the understanding of loss properties. For the $Fe_2O_3$ doped PMnS-PZN-PZT ceramics, however, the characteristics of the domain wall motion are still remained to be clarified.

In this study, the high-field dielectric and piezoelectric nonlinearities of $Fe_2O_3$ doped PMnS-PZN-PZT piezoelectric ceramics are investigated. To characterize the domain wall motion, the electric field dependent dielectric and piezoelectric constants are analyzed in terms of Rayleigh law. Results show that with the increase of electric-field level, both the dielectric and piezoelectric constants deviate their low-field values and exhibit increase trends, due to the enhanced domain wall motion at high field. Rayleigh analysis reveals the contribution from lossless reversible domain wall motion to the high-field nonlinear dielectric and piezoelectric properties in $Fe_2O_3$ doped PMnS-PZN-PZT ceramics. This behavior could be associated with the orderly distribution of defect pinning centers, and is thought to be responsible for the low losses of the ceramics. The effects of temperature on high-field dielectric nonlinearity is also investigated. It is found that the high-field dielectric nonlinearity is enhanced with the increase of temperature. This phenomenon is explained with the increase of the mobility of the oxygen vacancies and the randomization of the defect pinning centers at elevated temperatures.

1. S. Zhang, J.B. Lim, H.J. Lee, et al., *IEEE Trans. Ultrason. Ferroelect. Freq. Contr.* **56**, 1523 (2009).
2. K. Uchino, J.H. Zheng, Y.H. Chen, et al., *J. Mater. Sci.* **41**, 217 (2006).
3. J. Mao, J. Zhou, H. Zheng, et al., *J. Synth. Cryst.* **39**, 72 (2010).
4. G. Liu, S. Zhang, W. Jiang, et al., *Mater. Sci. Eng. R* **89**, 1-48 (2015).